

# FEASIBILITY AND USER ACCEPTANCE OF A PERSONAL WEIGHT MANAGEMENT SYSTEM BASED ON UBIQUITOUS COMPUTING

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**Abstract** - With the fast development of information and communications technology, devices with some computing power are becoming increasingly abundant in the average home. The trend for these devices to also be provided with inter-communication functionality opens up new possibilities for health care. The availability of ubiquitous computing allows the individual to perform health-related measurements, review data or consult guidelines independent of place or time, thus providing the individual with a better means to follow certain treatment programs.

In this study, we set out to implement a system based on ubiquitous computing for the application of weight management using behavioral feedback. The goals were a) to gain insights in the technical feasibility and caveats of such a system as a basis for setting up more advanced and generic infrastructures, and b) to study the degree to whether people are actually willing to use such a technology-laden system for their health management.

The results lead us to the conclusion that such a system is possible with the current technology, although many issues need to be solved before generic architectures and implementations are a reality, and that many people, especially those who have serious weight problems, are eager to use such a system.

**Keywords** - weight control, self-monitoring, behavioral feedback, home health care, wireless communications, ubiquitous computing.

## I. INTRODUCTION

The fast developments in the performance and cost-effectiveness of information and communications technology (ICT) and related electronics enable more and more everyday appliances to be equipped with some processing power and to become communicative. This trend may be looked upon from different perspectives. From the telecommunication's viewpoint it may be defined as connecting everything to everything else; it may be foreseen that soon the intercommunication between devices becomes more common than, the currently predominant, person-device and person-person communication. From the hardware viewpoint, we see an increasing dissemination and integration of sensors, actuators etc. into every-day appliances; in a modern home tens of embedded computers in cars, toys, white goods, entertainment electronics, etc. can be found. Finally, from the human viewpoint, the introduction of *ubiquitous computing* enables a shift from interactive, human-centered computing into *proactive, human-supervised computing*, which in the long run will lead to *calm computing*. This means that the

user is no longer explicitly aware of most of the computing taking place but the interaction with the environment is natural and intuitive.

The invasion of mobile phones and personal digital assistants (PDAs), wireless networking developments, and introduction of home networks and gateways is enabling a completely new kind of services to be offered for nomadic as well as home-based usage. Some of the main questions in this revolution are: what is the killer application, what kind of services are people waiting for, and how should such services be provided to them?

Parallel to the development of ICT, the health care system is also changing. The main driving force for these changes is the health care cost crisis encountered in many countries. New concepts like health and disease management, telemedicine, and home hospital are being introduced. The key factors in these concepts are 1) pervasive provision of health care services independently of time and locations, and 2) active involvement of the patient in his/her health care or wellness management. Both are supported by the above-described revolution of ICT. Hence, health care and personal health and disease management are high-potential application areas for ubiquitous computing [1].

In the prevention and management of many common diseases, such as cardiovascular diseases and diabetes, the life style and other self-managed factors play an essential role. However, life-style changes alone are seldom successful and other treatments such as continuous medication are needed. The lack of success is not due to lack of information available to the patients [2] but rather a lack of sufficient and maintained motivation to adopt and keep the healthier life style. It may be argued that any efforts to increase and maintain this motivation for healthier life style would be essential in personal health and disease management.

A good example of this is the case of weight management. Overweight is a significant risk factor e.g., for cardiovascular diseases and diabetes. However, only about half of the population of the European Union is within normal weight range and more than 40% are either over-weight or obese [3, 4]. There is a tendency of more and more people being in a state of weight gain rather than weight loss [5]. The health care system has obvious difficulties to provide treatments and advice to such large number of people. One of the main problems in weight management is that it is easy to gain back weight after starting a weight control program. Actually, a majority of people gains back their weight within five years after starting the weight control program [6]. A behavioral model of eating may provide some new suggestions to the weight control problem [2]. According to the behavioral

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view, eating and consequently weight may be modified or changed by the individual's own experience, on the basis of self-monitoring. From this perspective, weight management requires continuing measurements, at home and on the move, during workdays and during holidays. To implement this in a way that it can be used effortlessly by the individual calls for pervasive and ubiquitous methods.

The objectives of this study were to 1) design and implement a personal weight management system implementing the behavioral feedback model using ubiquitous computing, and 2) study the user acceptance for the designed concept and the services it is providing.

## II. METHODOLOGY

### A. Behavioral feedback model and weight management

In the behavioral feedback model eating and exercise, and thus weight may be modified by using the individual's own experience (Fig. 1). In this view, self-monitoring is central for successful weight control [7]. However, also information in the form of rules, advice, and others' experiences are widely used resource in weight control programs. This information is however not used optimally; mainly because the effects it describes are temporally too far removed from the actual situation to which it applies. Guidelines on how to deal with situations like Christmas dinners have limited effect when they were read in July, or, when one would want to know the calorie contents of a certain food stuff, it is most critical that this information is available on the spot. Thus, the availability of this type of information should be temporally be as close as possible to the actual eating behavior.

In summary, according to the used model, the success of weight control hinges on:

1. self-monitoring and providing feedback to the individual thus allowing the individual to learn more effectively by his/her own experience, and
2. a possibility to receive immediate information and expert advice on eating habits, effects of exercise etc.

Ubiquitous computing is being used as the enabling technology to fulfill those requirements. Recording and viewing of the data can be done effortlessly anywhere and at any time using a mobile phone or PDA and wireless communication between the participating measurement devices. Access to information on eating habits etc. is

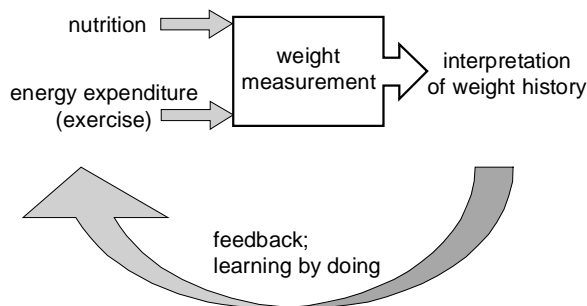


Fig. 1. Behavioural feedback model for weight control

available on the spot as well by using data transfer via the mobile phone.

### B. System design and services

Our vision is that in the future, wireless home networks will be available in many homes. The nomad user may remotely connect to his/her home by using his/her handheld user interface, which may be e.g. a mobile phone or a PDA. The core of the home network will be a home server with processing power comparable to PCs. The home server will also provide space for data storage and a gateway to the Internet. Wireless terminals will be able to access the home network locally (e.g. using Bluetooth) or remotely (e.g. using Internet). Measurement devices will be able to join the home network and send the acquired data to the home server for storage, analysis and display. A wireless home network will allow peripherals (e.g. measurement devices), wireless terminals (e.g. smart phones) and data storage devices to communicate wirelessly. Based on this vision, we built a prototype (Fig. 2) with currently available hardware and software.

The *home server* is a PC with a WLAN access point. The *measurement devices*, a scale and a heart rate monitor, can join the home network via a proxy, which is a portable computer equipped with a WLAN card. Two *wireless terminals* are used; a portable pen computer with a WLAN card and a WAP enabled cellular phone. The core of WWM software runs on the home server as a collection of Jini services implemented using Remote Method Invocation (RMI). The system is described in more detail in [8].

The system provides the following services: 1) a behavioral feedback system for recording and monitoring weight and physical activity/exercise; 2) a database containing energy contents and expenditure data for nutrition

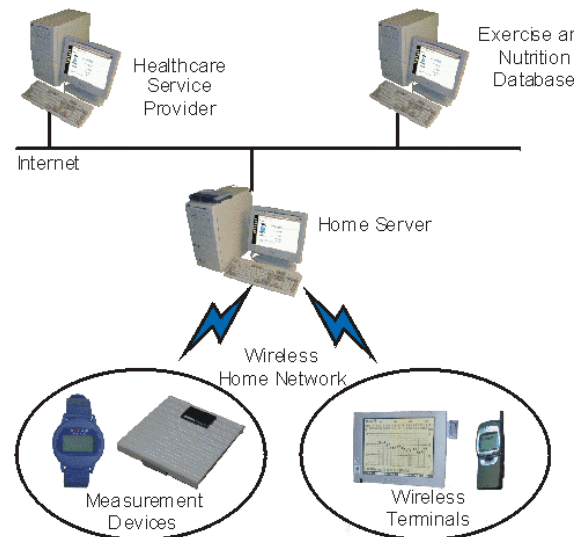


Fig. 2. The home network relies on the Wireless Local Area Network (WLAN) technology.

and physical exercise; 3) a database for behavioral instructions including guideline on weight management; and 4) an expert service system which allows the individual to contact a clinician, share data etc. In this project the main emphasis was on the development of the *behavioral feedback system*, which includes functions to measure, store and display graphically (provide feedback) the trends of weight and heart rate in on various time scales (Fig. 3). It can be accessed over WLAN or using GSM/WAP-interface.

The *nutrition and exercise database* can be accessed with a WAP browser and it provides calorie information of food items and energy expenditure information about different exercises. Calorie comparisons between two food items (e.g., 100g of chocolate vs. 100g of raisins) can be done as well as energy expenditure comparisons between two different exercise types (e.g., jogging vs. tennis). An exercise and a food item can be compared. For example, one can see how long one has to jog to burn the calories gained from eating one chocolate bar. Alternatively, one can see how much raisins have to be eaten to have enough energy for a 4 hour marathon. The basis for this information is the Finnish Nutrition Database FINELI [9]. The *instruction database* containing e.g. a keyword search of weight management guidelines and tips has not yet been integrated to the system. The *expert system* uses GSM or Internet-based means of establishing contact between clinician and patient.

### C. User survey

Once a prototype system was implemented, a study was performed, mainly on the basis of using mock-ups of situations, to find out how potential users evaluated its services. The focus was on the users' opinions about the usefulness of the content, i.e., to find out if the services were what the users needed and in how far they regarded the system as useful and easy to use.

Twelve (12) persons (9 women and 3 men, age between 23 and 61) were interviewed. Three persons had no past or present weight problem, while the others had or had had overweight. Three men and two women had never tried to lose weight, but the remaining persons actively managed their weight or had done so at some point in life. Two of the interviewees had no experience with computers, and one person did not have a mobile phone. All other persons had

plenty of experience with mobile phones and from basic to very good skills in using computers.

Structured theme interviews with the duration between 30 and 90 minutes were used. The interviewer first explained briefly the idea behind the weight management system and the general functionality of the services it provides. After this, he went through all four services one by one with the interviewee. The qualitative data obtained from the interviews were analyzed by classifying them into emergent categories.

## III. RESULTS

### A. System implementation

The system as described in Section II.B was implemented in a 'laboratory' environment. In this context this means that all functionality is provided, but some of the hardware components are early versions or place holders for integrated components that are expected to be on the market soon but were unavailable within the time frame of the project. For example, scales or heart rate meters with the needed integrated wireless communication facilities are not on the market as of yet, forcing usage of PC with WLAN cards connected to the devices to implement the functionality. Also the current state of the WAP infrastructure made certain parts of the implementation less elegant than what would be required when creating a system that would be ready for the market. Nevertheless, the required functionality is implemented, and as such the system provides a statement about the technical feasibility of such a system and provides a testbed for evaluation and to build further upon.

### B. Evaluation of usability of the system

In general the interviewees evaluated the system positively. The services were regarded as useful and the interviewees did not see any critical problems associated with the services. However, the nutrition and exercise database was thought to be less useful than the other services. The behavioral feedback system and the expert service interface were seen as the main motivating factors to start using the system.

Four of the interviewees spontaneously mentioned the mobile aspect of the system as a benefit. The benefit they mentioned was the increased availability of advice (from database services) in difficult situations, e.g., at dinner table or during grocery shopping.

The interviewees evaluated the services as easy to use. The person's skills in using a computer and mobile phone did not affect the perceived ease of use. The price of the service emerged as one potential problem. Especially those interviewees with lower income expressed their worries about the costs of using the service. The interviewees thought that the most probable user groups would be younger people and women. General arguments for these were that young people are more technology-savvy, and that women are more interested in weight control issues than men.

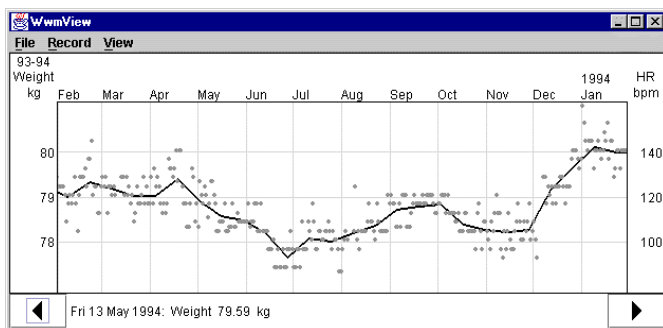


Fig. 3. Trend graph of behavioral feedback system.

The interviewees were also asked to estimate the likelihood that they would be using the system still after one year once they had started using it, and also to estimate how many days per month they would use the system's services. Persons that had weight problems estimated the likelihood that they still would use the system after one year to be 80 % and the persons without weight problems 63 %. On average interviewees estimated that they would use services 18 days a month (ranging from 4 to 30).

#### IV. DISCUSSION

The implemented system provides us with a view on how an environment in which computing resources are abundant can be used in the context of a health-related problem; in this case weight control using behavioral feedback. Such a system allows us: a) to evaluate technical merits of 'ubiquitous computing' at this moment, b) to identify certain problems that need to be dealt with for such a system to be viable for use on a wider scale, and c) to provide ideas for further development in the area of ubiquitous computing both in the sense of "smart contents" as well as "enabling technologies".

The main idea behind using behavioral feedback system is that receiving feedback regarding the consequences of one's behavior will increase the motivation to continue with weight monitoring. This seems to hold true with our interviewees. Four persons explicitly stated that the service would increase or maintain their motivation to keep controlling their weight. In similar vein interviewees reported that the feedback system would help to make weight control more interesting. Several people saw the graphic display system as beneficial as it makes changes in body weight more concrete. However, the study is based on a fairly small sample (12 persons) and made use of mock-ups to describe certain situations, and thus one has to be rather cautious when making generalizations.

The behavioral feedback system was also considered useful in long term planning and goal setting in weight control. People saw that the system would help them monitor changes in eating habits and diet throughout the year. Also it would help the users to follow weight level after successful diet and help maintaining desired weight level. However, it is worth noting that the high positive acceptance figures given in the results section might partially come from a positive response bias (persons overestimated their use of the system in their answers). Concerning the nutrition & exercise database, the question that has to be considered carefully is to whom the service is really useful, and how large is this user population. Another important question is whether the system works so that it really saves time as compared to traditional means. The instructions database holds a good promise for an additional value service, but it needs to be developed into a comprehensive and large information service. The expert service was found to be motivating and useful, but again, the question is: who needs the service, and at the same time be ready for the increased social commitment? It seems likely that the most probable users for this service would be those who have rather serious weight control problems.

#### V. CONCLUSION

The project demonstrates the application of both ubiquitous and behavioral psychology in order to solve practical problems in health management and wellbeing. This project is an example of how the use of currently available technology can also provide behavioral management solutions, which were not possible earlier. The chosen application, weight control, is just one of the possible application areas in which this set-up can be used. In principle any type of measurement device could be used instead of the scale and heart rate meter.

In the user interview study the ideas of the system received positive evaluations. However, the final value of the system will be found out only when a large number of users actually has access to the service and can try it out in real-life settings. Important choices and issues need to be dealt with before larger scale implementation, these include choice of home server implementation (PC or digital-TV set-top box?), wireless communications (Bluetooth, WLAN?), security and privacy issues as well as questions concerning the business model to be used. International standardization efforts are needed to deal with these issues.

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